As, when the cornea is inflamed, inflammatory congestion of the conjunctiva and sclerotica takes place, so in like manner, when an interstitial morbid process commences idiopathically, congestion of the white of the eye next the affected part of the cornea shows itself. This is owing to reflexion of the irritation of the sensitive corneal nerves to the vaso-motor nerves of the arteries of the adjacent conjunctiva and sclerotica. These arteries thereby become constricted, and inflammatory congestion takes place in the manner before explained.

ARTICLE XIII.

A CONTRIBUTION TO THE CLINICAL HISTORY OF MYOPIA.

By S. D. RISLEY, M.D., Lecturer on Ophthalmoscopy in the University of Pennsylvania; Ophthalmic and Aural Surgeon to the Episcopal Hospital at Philadelphia.

IN the domain of ophthalmology no malady is of greater interest to the surgeon, or of graver import to every civilized community than that of *progressive myopia.* The extreme frequency of its occurrence; the known fact of its acquisition during early life; and its apparently intimate relation to the educational process, have, together with the uncertainty which still hovers over its clinical history, served to elevate it to a first place among the many vexed problems presented to the ophthalmic surgeon for solution. Its great importance has led to the most extended observation and careful collection of statistical information, in the hope that by this means the causes of its production might be discerned and removed.

As early as 1813, James Ware published in the *Philosophical Transactions* his results from the examination of the eyes of 10,000 soldiers. He was followed by numerous other observers, until, in 1876, no less than 52,478 persons had been examined by foreign observers (Emmert). To this large number are to be added the labours of Drs. Derby, Loring, Cheatham, Williams, Prout, and Matthewson, and my own as yet unpublished statistics, in this country. By these extended observations it has been shown conclusively that the percentage of myopia steadily increased from the lower to the higher classes. Thus, in St. Petersburg, Professor Erismann found in 4358 scholars, 13.6 per cent. of myopia in the primary, which had increased to 42.8 per cent. in the higher classes. In Germany the rise was from 11.1 per cent. to 62.1 per cent. The American statistics already published furnish a more favourable result than the above, but are, nevertheless, sufficient to excite the gravest foreboding; commencing, as they do, with myopia of 3.55 per cent., and rising to 26.79 per cent.

Thus far, however, the results attained by all observers agree in the main fact that during school life the percentage of myopia steadily and rapidly increased. Beyond this, however, but little information was gained. It is true, many important deductions were made from the carefully collated statistics, which it is not now our purpose to discuss. It also led to much important discussion regarding the hygienic surroundings of school children, and very much of great importance has been written regarding the lighting, seating, text-books, etc., but regarding the essential cause of myopia, and its individual history, it was necessary to do more than examine large numbers of eyes at different ages and different stages of advancement in school-work. The requisite insight into its cause and true history could only be gained by the successive examination of the same eyes at different stages of the educational progress. It was only by such observation that it could be proven beyond peradventure that emmetropia had given place to myopia, or that a hypermetropic eye had become emmetropic or myopic. It was only by this means that the pathological conditions, if any were present, could be traced, and their due importance assigned. There were very obvious difficulties in the way of such observation, but difficulties by no means insuperable. It is to be regretted that a decade has been allowed to pass without the repeated examination of the lower classes, examined by earlier observers, and now constituting the higher grades. In view of the great importance of such observation, I have regarded the following three cases of sufficient value to be placed upon record in the annals of this subject, since any number of cases, however small, in which the actual change from one refractive condition into another was accurately observed, furnish no uncertain light, but are a sure guide toward the truth.

These cases came to me suffering from eye-strain, and the very usual accompanying condition of retino-choroidal irritation or inflammation. A careful measurement under a mydriatic, used until complete paralysis of the accommodation was secured, revealed hypermetropic refraction. A subsequent examination, also made with paralysis of the ciliary muscle, showed an absolute myopic refraction. Two of these cases were situated under the most favourable hygienic surroundings; the third was a medical student, and was subjected to the extraordinary demands of a medical student's life.

CASE I. *Simple Hypermetropic Astigmatism, which under observation gave place to simple Myopic Astigmatism, the meridian of greatest refraction being retained.*—Emily S., æt. nine and a half years, was brought to me in November, 1878, by the advice of her music teacher, who discovered that the child had great difficulty in reading the notes, and believed it was because of her inability to see their position upon the staff. She had also to place her face so near to the sheet in order to see the music at all, as to prevent the skilled and graceful use of the keyboard. She was large for her age; in robust health; living in a home of luxury, and given to out-door sports of the most vigorous kind. In spite of this she had made rapid progress in school, showing unusual intellectual precocity. The hours not actually devoted to out-door play were employed in reading and music. Many books of romance, etc., were eagerly devoured. In the subsequent progress of the case, where this practice was interdicted, she begged that she might at least read *but one book* each week. Her eyes were prominent, irides blue, sclera bluish-white, and the anterior episcleral vessels were injected. The balls, when turned strongly downward, seemed flattened or broader laterally than vertically. She insisted that her eyes were perfectly comfortable; that they were never tired, never pained her; that she never had headache. With each eye $V = \frac{20}{\text{LXX}}$. Jr. No. 1 was read, but with difficulty, from $3\frac{1}{2}''$ to $6''$. At $20'$ lines at 90° (or vert.) were distinctly separated; while at 180° they were blended into a gray stripe.

The ophthalmoscopic record made at that time is as follows: Vert. ves. *Em.*, hor. ves. —3 or 3.5 D in each eye. There is a small central excavation in each nerve, with anomalous emergence of the central vessels. There is a pigment line beyond the outer margin of the nerve in the right eye. The nerve surface was too capillary, and the choroid in places honey-combed.

She was given a solution of atropia sulphat., gr. iv–f℥j—to be instilled three times daily—and return. The following day *V* had somewhat improved for distance, but no satisfactory correction of the existing error of refraction could be made, so the atropia solution was continued. At this visit she volunteered the statement that her eyes felt a great deal better than before the drops were used—which was a remarkable statement in view of the fact that she had so positively disclaimed all discomfort before, even when urgently inquired of regarding it. To me it illustrated the fact, too frequently ignored, that children do not complain of suffering which would at once drive adults to seek for relief. I have too frequently seen school-children pursuing their daily duties in the public schools of Philadelphia with eyes in worse condition than half the people I had seen in my private office on the same day, yet uncomplainingly performing their severe tasks. My little patient, when only partly relieved from the spasm of the ciliary muscle, felt a comfort which, if ever experienced, she had forgotten. Repeated unsatisfactory attempts were made to select a correcting-glass. At first crossed cylinders were required; but finally, on the sixth day of instillation of the atropia solution, the myopic meridian entirely disappeared. Lines at 180° in place of 90°, as at first, were now distinctly seen, and at 90° faded into a gray stripe, and her correcting-glass proved to be for O. D. $+\frac{1}{13}^{\text{cy}}$ ax. 90°, O. S. $+\frac{1}{16}^{\text{cy}}$ ax. 90°. With these $V = \frac{20}{\text{XXX}}$ each eye, and not so well with any other glass or combination of glasses. Through them the choroidal epithelium was sharply seen with the ophthalmoscope. In short, after the most painstaking care in verifying the correction by numerous methods, I was entirely satisfied with the above as the correcting-glasses. The atropia was discontinued and the glasses ordered. They were to be mounted as spectacles, carefully centred, and to be worn constantly.

Fourteen days later, and again in six weeks, she was seen, her glasses having been worn all the time. At each of these visits the sharpness of vision was recorded as $\frac{20}{\text{XXX}}$. Jr. 1 readily from $3''$ to $14''$, and the ophthalmoscopic record was, at the last visit, "fundus healthy." She was now allowed to return to school, but the glasses were to be constantly worn, and I believe this was faithfully done.

June 27, 1879. She was brought to see me to show how well her eyes were. I noted immediately that the episcleral vessels were dilated, and the ophthalmoscope showed a great increase in the absorption of the choroidal pigment, and that the nerve surface was almost as red as the choroid. The details of the fundus could not be distinctly seen through the correcting-glasses without an additional concave lens, and V had sunk to $\frac{20}{\text{LXX}}$ through them. A 2 gr. solution of duboisia sulphate was ordered to be used twice daily, a pair of smoked glasses to be worn out of doors, and she was sent to the country. In twelve days the condition of fundus was found greatly improved, and with her correcting-glasses $V\frac{20}{\text{XXX}}$. Careful measurement revealed no change in the refraction of the eye.

The duboisia was stopped, and she returned to their summer residence in the country. Three months later—one year from the date of her first visit—she returned with her eyes perfectly well; $V\frac{20}{\text{XXX}}$ with correcting-glasses as above. The intervening time had been spent with a governess, principally out of doors. All her instruction had been oral; she had not been allowed to read. Unfortunately she was now permitted to return to school, but was sent to a kindergarten conducted by a very intelligent German, and strictly after the Froebel system. She was forbidden to read out of school hours, and was allowed her music lesson twice a week and one hour of practice daily—a half hour each morning and afternoon. This was on September 25th. The following January 3, 1880, she was seen again. V had sunk to less than $\frac{20}{\text{CC}}=\frac{1}{10}$. The choroid and retina were once more in a condition of marked irritation, and still further inroads had been made upon the choroidal epithelium. It required for the left eye —2 D to get a sharp image of the fundus and —3 D for the right eye, viewed through the correcting-glasses. Without any glass her vision was $\frac{20}{\text{L}}$. The duboisia solution was again instilled, with the result of again improving the condition of the eye-ground. It was now noted that a marked change had taken place in the shape and size of the porus opticus. The central excavation—which I at first noted as a deep *physiological* excavation, which had at first been small, deep, and nearly circular, with a very irregular emergence of the central vessels—was now shallower, broader, and the peculiar irregularity of the central vessels had disappeared to a great extent. After the most painstaking care in measuring the principal meridians of the cornea, the following formula for glasses proved now to be the necessary correcting-glass:—

$$\text{For O.D.} + \tfrac{1}{16}{}^{\text{cy}}\,\text{ax.}\,105^\circ \;|\!\underline{\quad}\; -\tfrac{1}{30}{}^{\text{cy}}\,\text{ax.}\,180^\circ\; V=\frac{20}{\text{XXX}}$$

$$\text{O.S.} + \tfrac{1}{36}{}^{\text{cy}}\,\text{ax.}\;\;90^\circ \;|\!\underline{\quad}\; -\tfrac{1}{15}\;\;\text{ax.}\,180^\circ\; V=\frac{20}{\text{XXX}}$$

The duboisia, which had been used for ten days, was stopped and the above formula for glasses ordered, to be worn constantly. Four days later she returned with her glasses correctly ground and mounted, and with them, with both eyes, $V = \frac{20}{\text{XX}}$ through the now nearly normal pupils. She was now watched more carefully than before by requiring frequent stated visits at the office. The mydriatic was stopped on the 15th of January. On the 19th, four days later, $V = \frac{20}{\text{XX}}$ p. p. Jr. 1, $4\frac{1}{2}''$. This was steadily maintained until February 14th, when $V = \frac{20}{\text{XXX}}$. After examination with the ophthalmoscope it sunk to $\frac{20}{\text{XL}}$. The nerve-surface was once more too red. A single instillation of duboisia was made, and a week later the sharpness of vision was once more normal. On March 19th $V = \frac{20}{\text{XX}}$ each eye and the fundus healthy. On June 19th, three months having elapsed, during which time she had not been seen, she returned, and V had now sunk with the former correcting-glasses to

$$\text{O. D.}\ \frac{20}{\text{C}} \qquad \text{O. S.}\ \frac{20}{\text{LXX}}.$$

After a few moments' rest in the office vision rose to

$$\text{O. D.}\ \frac{20}{\text{LXX}} \qquad \text{O. S.}\ \frac{20}{\text{XL}}.$$

A concave glass was necessary to have a distinct ophthalmoscopic image of the fundus. After three days' use of duboisia the following change was found to have taken place in the refraction. In O. D. the hypermetropic meridian had been reduced from $H = \frac{1}{16}$ to $\frac{1}{60}$, while the myopic meridian had increased from $M = \frac{1}{30}$ to $\frac{1}{14}$. In O. S. the hypermetropic meridian had entirely disappeared, and the myopic meridian had increased from $\frac{1}{15}$ to $\frac{1}{12}$.

She was then ordered for O. D. $+\frac{1}{60}^{s} \bigcirc -\frac{1}{12}^{cy}$ ax. 15°, O. S. $-\frac{1}{12}^{cy}$ ax. 180°; with these $V = \frac{20}{\text{XX}}$ in each eye.

Since writing the above (July 1st) this patient was seen, and V found to remain at $\frac{20}{\text{XX}}$.

Here then, directly under observation, a simple hypermetropic astigmatism of high degree, under carefully selected correcting-glasses, passed over into a corresponding degree of simple myopic astigmatism; the meridian which was at first emmetropic becoming myopic, and the hypermetropic meridian becoming emmetropic. Three times was its progress arrested by treatment, but the result is somewhat discouraging, since in spite of treatment and avoidance of work the distension of the ball still advanced. The mother of the child and a paternal aunt both had compound hypermetropic astigmatism.

The case is still under my care, and it remains to be seen whether the lengthening of the eyeballs will still go on into a compound myopic astigmatism. The question of hereditary myopia is excluded in this case, since no instance of myopia could be discovered in the family, and one member at least of each side of the family was proven to be hypermetropic. There was doubtless an intimate relation between the undue eye strain, caused by the high degree of astigmatism present, and the choroidal disease. This in turn interrupted the nutrition of the ball, rendering the distension possible in this rapidly growing girl.

CASE II. *Simple HAs carefully determined under Atropia converted into compound MAs in one year and a half, also determined after Paralysis of Accommodation.*—H. H. K., æt. 17, male, student at Middletown, Ct., consulted me, Oct. 31, 1879, because of weak eyes and failing sharpness of sight. The eyes had become so painful that he had been compelled to withdraw from his college duties, unable to finish the school term. He had $V = \frac{20}{\text{LXX}}$ in each eye and saw horizontal lines best. There was no insufficiency of the internal rectus muscles. The nerve surface in both eyes was intensely capillary, the retina striated and hazy around the nerve, especially along the course of the great vessels and over the inner margin of the nerve which was quite obscured. In O. D. there was a yellowish-red crescent of choroiditis, one-half the width of the disk, embracing its outer half. In O. S. there was a narrower crescent of interrupted pigment deposit, also embracing the outer margin of the nerve. The refraction was noted as myopic astigmatism. The highest meridian, however, was seen with —2 D.

He gave the following history: In March, 1877, during a preparatory course of study at Rugby Academy, in Philadelphia, his eyes had failed him. He consulted Dr. Wm. Thomson, of Philadelphia, who after careful determination under atropia ordered for him
O. D. $+\frac{1}{60}^{\text{cy}}$ ax. 15°.
O. S. $+\frac{1}{60}^{\text{cy}}$ ax. 160°.

With these he returned to his work, and was able to prosecute his studies without the least difficulty during the spring and autumn of 1877 and the remainder of the school year in 1878. His glasses, however, had been worn faithfully both for distance and near work. In the summer of 1878 he went to the sea-side, either forgetting or purposely leaving his glasses at home. This he subsequently regretted, but at the time supposed they were no longer necessary, since "his eyes were perfectly well." During the summer he worked persistently preparing for the fall examinations for entering college. He entered upon the duties of his freshman year with much enthusiasm. His eye troubles soon began again and grew rapidly worse until the last of October, when he gave up the painful contest and sought my advice about his eyes. He was in other respects apparently in perfect health. He was given a saline cathartic, a dry cup daily to each temple, and a solution of duboisia gr. ij–f℥j, to be used three times daily. A pair of coquille glasses, dark medium London smoke, were ordered to be worn when in the light. Repeated unsatisfactory attempts were made to correct the error of refraction, until finally on November 19th, after twenty days' use of the drops, part of the time but twice daily, the duboisia was stopped, and the following formula for correcting-glasses ordered to be worn constantly:
O. D. $-\frac{1}{36}^{\text{s}} \supset -\frac{1}{72}^{\text{cy}}$ ax. 105°.
O. S. $-\frac{1}{36}^{\text{s}} \supset -\frac{1}{72}^{\text{cy}}$ ax. 75°.

With these $V \frac{20}{\text{XX}}$ each eye, $\frac{20}{\text{XV}}$ with both. His eyes were now entirely free from pain and photophobia, and his fronto-occipital pain had disappeared. The ophthalmoscope marked a corresponding improvement in the fundus. The retinal haze had diminished, although much of the striation remained. The yellowish-red crescent in the right eye had almost faded from view.

He was detained from college until January. On January 31, 1880, $V=\frac{20}{xx}$ each eye with the above glasses, and there was no discomfort of any kind. On the 8th of September he was still entirely comfortable after two terms at school, and $V=\frac{20}{xx}$. His glasses had been worn constantly.

Two lessons are emphatically taught by this young man's history: first, that a hypermetropic eye may become a myopic one; second, the extreme importance and efficacy of careful correction of low degrees of astigmatism. It is almost certain that, had he adhered to the use of the weak cylinders ordered by Dr. Thomson, throughout his school life, or until he had gained his physical majority, he would have been spared his myopia.

It will be noticed further that the meridian of highest myopia, as in the case of Emily S. (Case I.), was the originally emmetropic meridian; the axis of the concave cylinders being placed at right angles to the axis of the convex cylinders at first required. It is highly probable that if his eyes had been neglected his myopia would have continued progressive, and that the crescent of choroiditis would have developed into a typical atrophic conus.

It will be of interest to record here that the father of this young man had $H = 1$ D in each eye with an astigmatism $= .5$ D in the right and 1 D in the left eye, axes of cylinder being placed at 105° and 75°. An older brother had $H = 1$ D in one eye, HAs .75 D in the other eye. A younger sister had a simple HAs in both eyes $= .75$ D, and the axes of the cylinders were required at 45° and 135°, corresponding very closely to the glass ordered by Dr. Thomson for her brother—the subject of this record. Both of these, the first a theological student, the other attending a seminary for young ladies, were compelled to leave their studies with marked choroido-retinal irritation and severe headaches aggravated by eye work. The young man had been advised to give up his books for travel—his headaches being ascribed to *overwork*. They were both entirely relieved by their correcting glasses. They were both averse to wearing them, especially the young lady; but after repeated trials she frankly and tersely acknowledged that she was convinced that she had her choice between the glasses, or weak eyes with headache. I could discover no history of myopia in the family. The mother has a high degree of hypermetropic astigmatism, and has always been a victim of "nervous headache."

CASE III. *Hypermetropia with High Insufficiency of the Interni, converted into Myopia in both Eyes with low degree of Astigmatism in the Left.*—C. H. B., æt. 24, medical student, came to the University dispensary service on January 28, 1876. He was a first year student, and entirely unaccustomed to the sedentary habits now forced upon him. His eyes had broken down under his work in the middle of his first term. The conjunctivæ were injected, he had headache and photophobia, aggravated by near work. Could still read for a short time by daylight; not at all, without great suffering, by gas-light.

$$\left.\begin{array}{l}\text{O. D. } V=\dfrac{20}{\text{LXXX}},\text{ Jr. 1, } 5'' \text{ to } 20'' \\ \text{O. S. } V=\dfrac{20}{\text{LXIV}},\text{ Jr. 1, } 5'' \text{ to } 20''\end{array}\right\}-\tfrac{1}{60}\quad V=\frac{20}{\text{XX}}$$

with vertical diplopia there was lateral crossed deviation $= 6^\circ$. In both eyes the retina was striated and nerve too capillary. There was disturbed pigmentation of the choroid at the outer or temporal side of the nerve in O. D., and an irregular black pigment band embracing the inner half of the nerve. In O. S. there was a grayish-green broadening of the scleral ring extending downward and outward. After prolonged atropinization the sharpness of vision gradually increased until the normal $\frac{20}{\text{XX}}$ was reached, and finally a convex glass was selected $(+\frac{1}{48}.)$ It was then noted that the retina had gained its normal transparency. The atropia instillations were stopped, and he was to be further tested for his insufficiency of the interni after the return of the accommodation. He became discouraged, however, and consulted an oculist, who gave him $-\frac{1}{48}{}^{\text{s}}$ to wear over each eye for distance, no atropia being used, and later prisms of 1.5° over each for reading—and allowed him to return to his books. He steadily grew worse, however, and his prisms were steadily increased until he wore 8° prism over each eye, and finally the externi were divided and his glasses dispensed with. He was relieved in great measure by this procedure, but was at no time able to use his eyes comfortably. He, however, succeeded in passing his examination, and after graduation he became resident physician in one of the city hospitals.

In Jan. 1880, just four years from the time he had applied for treatment at the University Hospital Dispensary, he entered my private class in ophthalmology. I soon discovered that he had great difficulty in using the ophthalmoscope, and on examining his eyes discovered a myopia of 1.5 D to 2 D. He then reminded me that four years before he had been under treatment at the dispensary. I consulted the record of his case, and found the history above given. He was then invited to my office, and a painstaking correction under duboisia made, and the following glasses ordered :—

$$\text{O. D. } -\tfrac{1}{30}{}^{\text{s}} \qquad\qquad V=\frac{20}{\text{XX}}$$

$$\text{O. S. } -\tfrac{1}{42}{}^{\text{s}} \bigcirc -\tfrac{1}{72}{}^{\text{c}}\text{ ax. } 30^\circ \qquad \frac{20}{\text{XX}},\text{ for constant wear;}$$

and—

$$\begin{array}{l}-\tfrac{1}{90}{}^{\text{s}} \bigcirc \text{ Pr. } 3^\circ \text{ base in} \\ -\tfrac{1}{72}{}^{\text{cy.}} \bigcirc \text{ Pr. } 3^\circ \text{ `` `` for reading.}\end{array}$$

He has since been entirely free from trouble with his eyes, and the constant frontal pain which he had suffered for four years was removed. The black pigment band at the inner side of the right nerve had been to a great extent absorbed, and presented now an irregular succession of pigment heaps with intervening grayish white spaces, and the choroidal circulation was visible throughout a large part of the choroid from absorption of the pigment epithelium.

CASE IV. *Hypermetropic Refraction converted into Myopic Astigmatism.*—Since the above cases were put in type, I was consulted by a gentleman, æt. 28, for whom, in 1875, I had prescribed under a mydriatic convex glasses for reading. He used them for two years with perfect comfort. He then accepted a clerkship, and worked in a dark office through business hours. His headache and weak eyes, for which he had at first consulted me, soon returned, but he worked on in spite of his discomfort until September 1, 1880. I found him with $V=\frac{20}{\text{CC}}$, made worse by his glasses. The ophthalmoscope revealed marked choroido-retinal disturbance. After prolonged use of the mydriatic V increased to $\frac{20}{\text{L}}$, and the actual refractive error was corrected by $-\frac{1}{72}^{\text{sp}} \bigcirc -\frac{1}{72}^{\text{cy.}}$ ax. at 90° in each eye with which glass $V=\frac{20}{\text{XX}}$.

The history of these cases proves at least the possibility of hypermetropic refraction giving place to myopia. In Cases I. and II. the existing astigmatism at the start, and the resulting change in the refraction, it is believed sustained to each other the relation of cause and effect. In Case III. the high insufficiency of the internal rectus muscles was probably the cause of the myopia, since the low degree of simple hypermetropia $=\frac{1}{48}$ was not sufficient to have caused his severe asthenopia and choroidal disease. When first seen the low acuity of vision — $\frac{20}{\text{LXX}}$ was due to spasm or persistent contraction of the ciliary muscles, since under the mydriatic the acuity steadily increased to the normal standard, and once more fell below it, and a convex glass was required.

The muscles of accommodation and convergence being under the same innervation he found it impossible to exert the necessary force with the weakened internal recti to avoid diplopia without, at the same time accommodating for a relatively too near point, thus simulating myopia, preferring an indistinct single image to double images, this being the only alternative. The constant tension thus maintained soon brought about the choroidal irritation, and produced the severe asthenopia. The myopia at first consisting only of tonic contraction of the ciliary muscle and increased convexity of the lens gave place finally to an actual permanent distension of the eyeball with semi-atrophic changes in the choroid as shown by the absorption of the large pigment crescent at the outer side of the nerve, and the honey-combed appearance of the entire choroid.